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# INSTRUCTION MANUAL

INSTRUCTION MANUAL
FOR
PROGRAMMABLE LOOP ANTENNA/COUPLER
MODEL 94593-1

(For Use With Model NM-17/27 FI Meter)

MANUAL NO. 1-500783-277
(For Use With Serial Numbers 101 and Above)

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SINGER
INSTRUMENTATION

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LOS ANGELES OPERATION
5340 Alla Road
Los Angeles, California 90066

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Electrical and Electronic Measuring Instruments..... 1 Year

Repair or replacement (at our option) without charge (F.O B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuses, lamps, thermoelements, and RatioTran potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

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5340 Alla Road, Los Angeles, California 90066

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## REPAIR AND MAINTENANCE

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Chargeable repairs: If requested, an estimate of charges will be made prior to repairs. Please provide us with the following information in order to expedite the processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble(1)
4. Approximate date instrument was placed in operation.
5. Approximate number of hours in use.
6. Has maintenance action been previously requested.
7. Other comments.

(1) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken and any other relevant data.

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Section I

# INTRODUCTION

## 1.1 GENERAL DESCRIPTION

The Singer Model 94593-1 is an electrostatically shielded Programmable Loop Antenna/Coupler, designed for use with a Singer Model NM-17/27 EMI/FI Meter. The Antenna Coupler and associated Collapsible Loop Antenna are calibrated for performing radiated magnetic field strength measurements within the frequency range of 10 kHz to 32 MHz. The antenna consists of the Loop Antenna Coupler, a mast section, three arms, and a length of modified coaxial cable.

## 1.2 MODES OF OPERATION

The Antenna/Coupler, Model 94593-1, is designed for either automatic band switching with the Model NM-17/27 supplying power or manual band switching operation with an external power supply.

## 1.3 ACCESSORIES

### 1.3.1 Supplied Accessories

The items listed in Table 1-1 are furnished with the Model 94593-1 Antenna/Coupler.

Table 1-1. Supplied Accessories

| Quantity | Device | Singer Part Number |
|---|---|---|
| 1 | Antenna Calibration Chart | 1-403692-001 |
| 1 | Instruction Manual | 1-500783-277 |

### 1.3.2 Required Accessories

For complete remote operation of the Antenna/Coupler, Model 94593-1, it is necessary to have the following accessories, in addition to the supplied accessories listed in Paragraph 1.3.1.

a. Antenna Control Cable, Model 94594-1, 20 ft., 19 pin to 41 pins. Connects the Loop Antenna/Coupler to the Model NM-17/27 for automatic remote band switching of the antenna.

b. RF Transmission Line, Model 92191-1, 20 ft., BNC to BNC. Used for connecting the RF OUTPUT receptacle of the Model 94593-1 Antenna/Coupler to the RF input receptacle of the Model NM-17/27 within a distance of 20 feet.

### 1.3.3 Optional Accessories

a. Collapsible Tripod, Model 91933-2. Used for mounting the Loop Antenna/Coupler for remote measurements.

Section II

# SPECIFICATIONS AND OPERATING CHARACTERISTICS

## 2.1 SPECIFICATIONS AND OPERATING CHARACTERISTICS

Table 2-1 contains specification data for the Model 94593-1 Loop Antenna/Coupler.

Table 2-1. Specifications and Operating Characteristics

| Parameter | Characteristic |
|---|---|
| Frequency range: | 10 kHz to 32 MHz in 8 bands<br>Band 1: 10 kHz to 250 kHz<br>Band 2: 250 kHz to 500 kHz<br>Band 3: 500 kHz to 1 MHz<br>Band 4: 1 MHz to 2 MHz<br>Band 5: 2 MHz to 4 MHz<br>Band 6: 4 MHz to 8 MHz<br>Band 7: 8 MHz to 16 MHz<br>Band 8: 16 MHz to 32 MHz |
| RF output load: | 50 ohm nominal |
| Programming power required: | -12 V ±1 V at 22 mA maximum |
| Shielding: | Electrostatic (Faraday) shield |
| Antenna Correction Factor: | See Figure 4-2 for typical data; also see Antenna Calibration Chart supplied with the Antenna/Coupler. |
| Mechanical:<br>Dimensions (including knobs, receptacles and loop antenna): | Approximate Height: 139 cm (53")<br>Approximate Width: 115 cm (46")<br>Approximate Depth: 11 cm (4") |
| Weight: | Approximately 1.3 kg (3 lbs) |
| Environmental:<br>Temperature: | Operational: -15°C to +50°C (+5°F to +123°F)<br>Non-operational: -50°C to +75°C (-58°F to +167°F) |
| Vibration: | Meets MIL-T-21200, Class 3 non-operating |
| Altitude: | Operational to at least 4570 m (15000 ft) mean sea level. |

Section III

# INSTALLATION

## 3.1 GENERAL

Assemble the Loop Antenna and attach to the Antenna Coupler as follows:

a. Insert the Mast Assembly, P/N S94031-1, into the Ferrule Base on top of the Antenna Coupler housing.

b. Insert the 3 Loop Antenna Arms, P/N S52707, into the 3 holes of the circular block at the top of the Mast Assembly, with the slotted ends outward.

c. Attach one end of the cable, P/N S94030-1, to one of the BNC connectors on top of the Antenna Coupler housing.

d. Thread the cable around the frame through the slots of the Loop Antenna Arms, and return the end to the remaining BNC connector on top of the Antenna Coupler housing.

e. The Antenna Coupler with Loop Antenna may be mounted on a Tripod, Model 91933-2, or equivalent tripod.

## 3.2 AUTOMATIC BAND SWITCHING OPERATION.

a. Connect the RF OUTPUT receptacle to the Model NM-17/27 RF INPUT receptacle using a Model 92191-1 or equivalent BNC cable.

b. Attach the Antenna Control Cable, Model 94594-1, between the receptacle on the side panel of the Antenna Coupler and the PROGRAMMER receptacle on the rear panel of the Model NM-17/27.

c. Set the Antenna Coupler BAND (MHz) switch to AUTO position.

d. The Model 94593-1 may now be operated remotely by the Model NM-17/27.

## 3.3 MANUAL BAND SWITCHING OPERATION

a. Remove the Antenna Control Cable connected between the Loop Antenna/Coupler and the PROGRAMMER receptacle of the NM-17/27.

b. Connect a 12 Vdc power source to the + and - binding post terminals mounted on the side of the Antenna/Coupler case.

c. Set the Antenna/Coupler BAND (MHz) switch to the frequency band desired.

> CAUTION
> Do not attach the Model 94594-1 Antenna Control Cable during manual band switch operation because the external 12 Vdc may interfere with the receiver circuitry.

Section IV

# OPERATING INSTRUCTIONS

## 4.1 GENERAL

Functional descriptions of controls and receptacles, instructions for using necessary accessory items, and operating instructions are presented in this section of the manual.

## 4.2 OPERATING CONTROLS, INDICATORS, AND RECEPTACLES

All external operating controls and receptacles are displayed in Figure 4-1.

Functions of the panel features are described in Table 4-1.

Table 4-1. Controls, Indicators and Receptacles, Model 94593-1

| Item | Panel Marking | Description | Function |
|---|---|---|---|
| 1 | RF OUTPUT | BNC connector (J3) | Provides RF output |
| 2 | BAND (MHz)<br>AUTO<br>.01 - .25<br>.25 - .5<br>.5 - 1<br>1 - 2<br>2 - 4<br>4 - 8<br>8 - 16<br>16 - 32 | 9-position rotary switch (S1) | Provides manual selection of the 8 frequency bands. AUTO position enables programmable selection of the bands. |
| 3<br>4 | | BNC connectors (J1, J2) | Provides input for Loop Antenna |
| 5 | | 19 pin connector (J4) | Provides program input for automatic band switching |
| 6 | + | Red binding post (J6) | Provides input for 12 Vdc required for manual band switching. |
| 7 | - | Black binding post (J5) | |

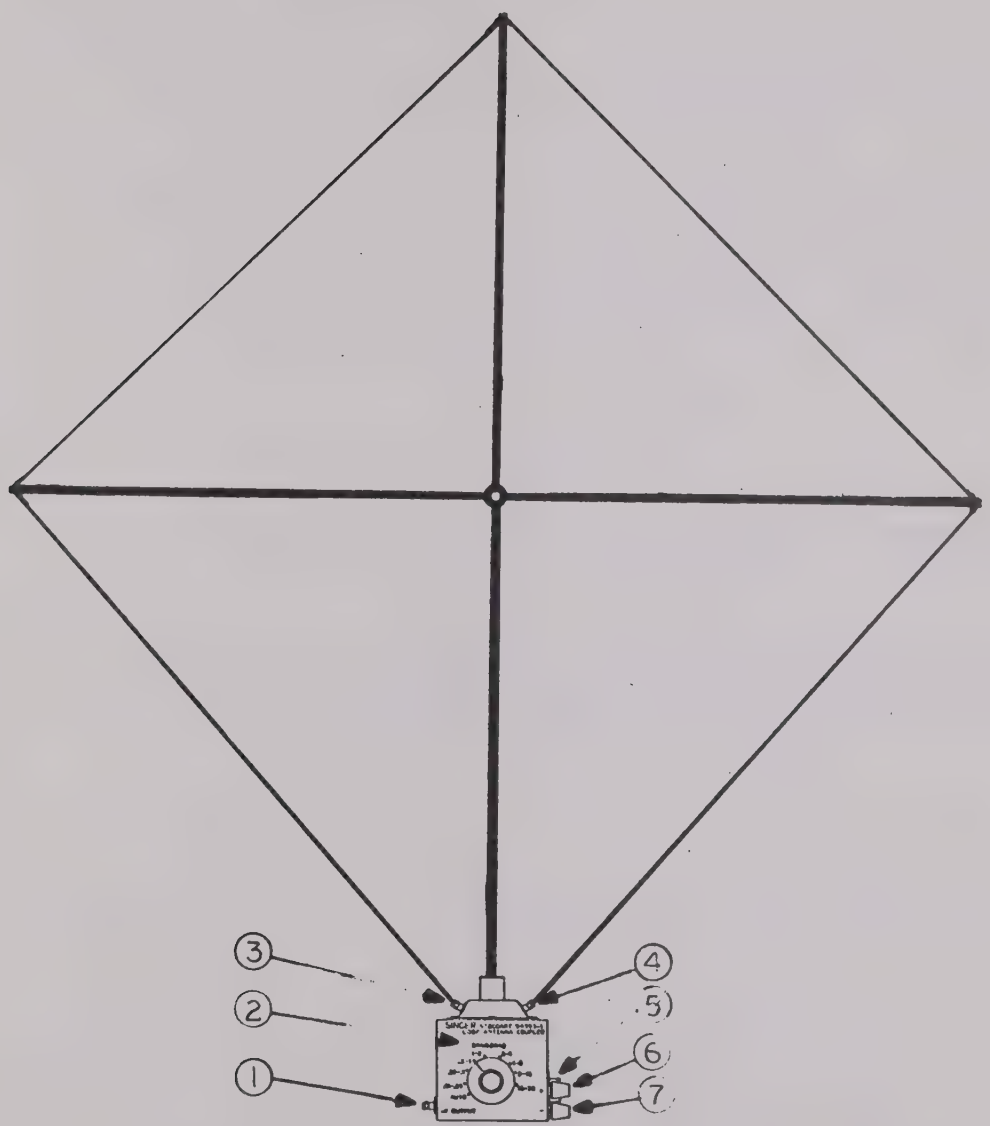



Figure 4-1. Controls, Indicators, Receptacles, Model 94593-1

## 4.3 OPERATING PROCEDURES

a. Install the Model 94593-1 Loop Antenna/Coupler as described in Paragraphs 3.1 and 3.2 or 3.3.

b. Set the BAND (MHz) switch to the desired band if the coupler is connected for manual operation. This step is not required for automatic operation with the Model NM-17/27.

c. Maximum signal voltage will be received by the Antenna/Coupler when the angle between the plane of the loop and direction of the signal source is 0 degrees. A minimum signal voltage will be received when the angle between the plane of the loop and direction of the signal source is 90 degrees. The theory of this phenomenon is explained in Paragraph 5.4.

d. Tune the receiver or EMI/Field Intensity Meter for maximum response to the desired signal.

e. Determine the voltage across the 50 ohm RF input to the EMI/ Field Intensity Meter in terms of dB related to 1 microvolt (dB$\mu$V).

f. Add the antenna correction factor (from the Antenna Calibration Chart supplied with the Programmable Loop Antenna/Coupler) to the voltage level noted in Step e to determine the field strength in terms of dB related to 1 $\mu$V per meter (dB$\mu$V/m).

## 4.4 CONVERSION OF TERMS

Table 4-2 lists conversion factors for magnetic field measurement units.

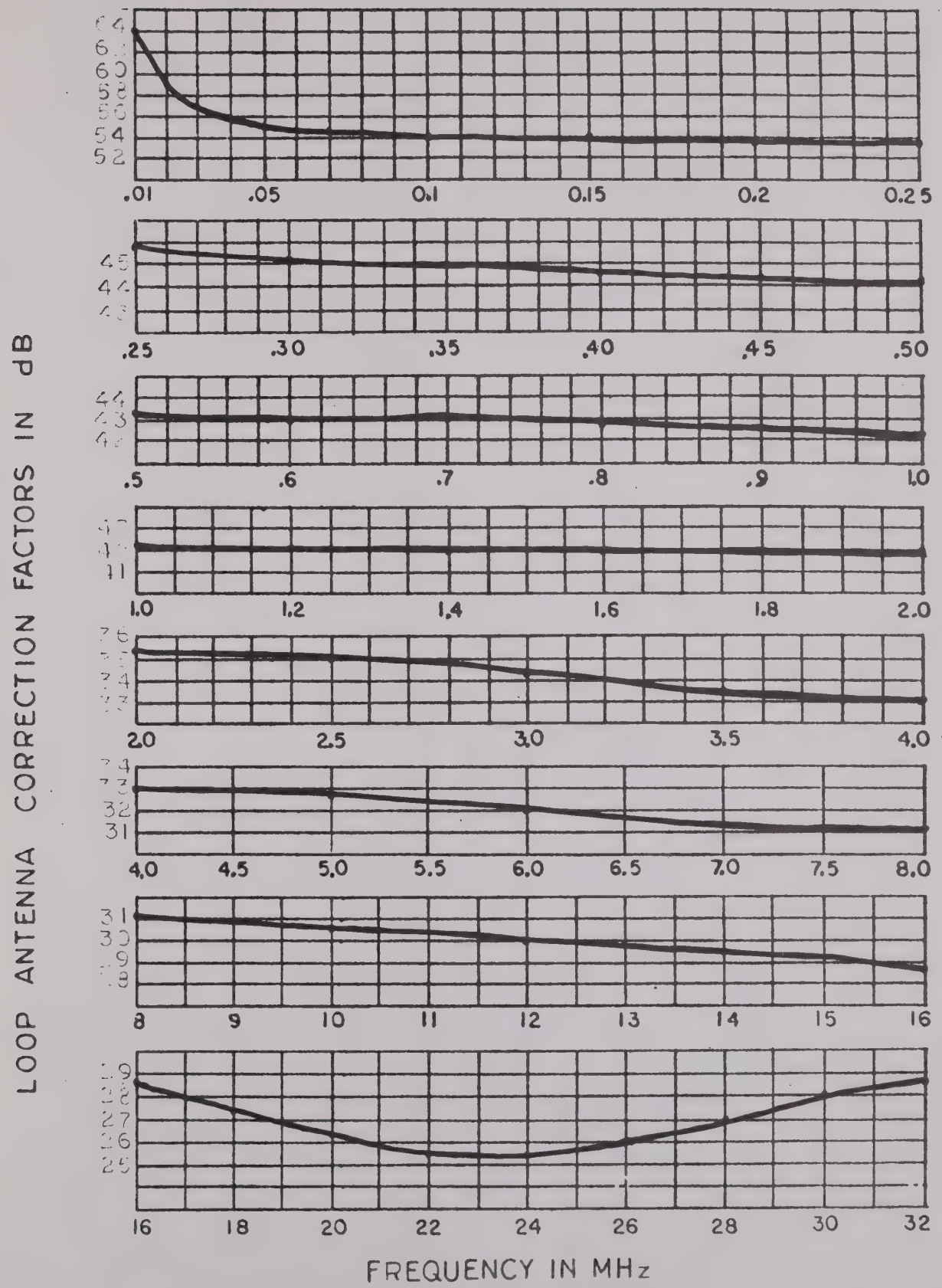



Figure 4-2. Typical Antenna Correction Factors, Model 94593-1

SAMPLE ONLY

Table 4-2. Magnetic Field Conversion Factors

| Algebraically add the indicated value to convert from ↓ to → | dBuV/m | dBGauss | dBpT | dBuA/m | dBWb/$m^2$ | dBgamma |
|---|---|---|---|---|---|---|
| 0 dB microvolts-per-meter = | 0 | -209.5 | -49.5 | -51.5 | -289.5 | -109.5 |
| 0 dB gauss (1) = | +209.5 | 0 | +160 | +158 | -80 | +100 |
| 0 dB picotesla = | +49.5 | -160 | 0 | -2 | -240 | -60 |
| 0 dB microampere-per-meter = | +51.5 | -158 | +2 | 0 | -238 | -58 |
| 0 dB weber per-square meter(2) = | +289.5 | +80 | +240 | +238 | 0 | +180 |
| 0 dB gamma = | +109.5 | -100 | +60 | +58 | -180 | 0 |

| Multiply by the indicated value to convert from ↓ to → | uV/m | Gauss | pT | uA/m | $Wb/m^2$ | gamma |
|---|---|---|---|---|---|---|
| 1 microvolt-per-meter = | 1 | $3.33 \times 10^{-11}$ | $3.33 \times 10^{-3}$ | $2.65 \times 10^{-3}$ | $3.33 \times 10^{-15}$ | $3.33 \times 10^{-6}$ |
| 1 gauss (1) = | $3 \times 10^{10}$ | 1 | $1 \times 10^{8}$ | $7.96 \times 10^{7}$ | $1 \times 10^{-4}$ | $1 \times 10^{5}$ |
| 1 picotesla = | $3 \times 10^{2}$ | $1 \times 10^{-8}$ | 1 | $7.96 \times 10^{-1}$ | $1 \times 10^{-12}$ | $1 \times 10^{-3}$ |
| 1 microampere-per-meter = | $3.77 \times 10^{2}$ | $1.26 \times 10^{-8}$ | 1.26 | 1 | $1.26 \times 10^{-12}$ | $1.26 \times 10^{-3}$ |
| 1 weber-per-square meter = | $3 \times 10^{14}$ | $1 \times 10^{4}$ | $1 \times 10^{12}$ | $7.96 \times 10^{11}$ | 1 | $1 \times 10^{9}$ |
| 1 gamma = | $3 \times 10^{5}$ | $1 \times 10^{-5}$ | $1 \times 10^{3}$ | $7.96 \times 10^{2}$ | $1 \times 10^{-9}$ | 1 |

NOTES:
(1) One gauss and one oerstead are equivalent and may be interchanged.
(2) One weber-per-square meter and one tesla are equivalent and may be interchanged.
(3) Decibel values are "rounded off" to the nearest 0.5 dB.

Section V

# THEORY OF OPERATION

## 5.1 ELECTRICAL DESCRIPTION

The Antenna/Coupler Model 94593-1 consists basically of a nine-position selector switch, two impedance matching transformers, and four relays.

## 5.2 RF CIRCUITRY

Refer to Schematic Diagram, Figure 8-1, for identification of component designations. RF signals are received at connectors J1 and J2 and pass through the impedance matching transformer applicable to the frequency band selected (i. e. A1T1 and A1T2) and then to the RF OUTPUT connector, J3. The pertinent relays (i. e. A1K1, A1K2) are energized as necessary by the power source circuitry. The RF signals are applied to the Model NM-17/27 from the RF OUTPUT receptacle, J3.

## 5.3 POWER SOURCE CIRCUITRY

The path of the RF signal is the same in manual or automatic band switching operation. The source of the voltage for energizing the relays, however, depends upon the mode of operation.

### 5.3.1 Automatic Mode

In the automatic band switching mode, the voltage is received from the Model NM-17/27 through the receptacle, J4. As the receiver is switched to a frequency band, -12 Vdc is applied to the appropriate relay which completes the RF path through the respective transformer for that band.

5.3.2 Manual Mode

In manual operation, the -12 Vdc relay voltage is applied from an external source to the + and - receptacles, J6 and J5. The appropriate matching transformer may now be selected by the BAND (MHz) switch, S1, which applies voltage to the proper relay. The frequency band position of BAND (MHz) switch, S1, should correspond to the frequency band position of the Model NM-17/27.

## 5.4 SHIELDED LOOP ANTENNA THEORY

When a loop antenna is used in practical circuits, it is generally near grounded surfaces and connected to the receiver through a transformer coupler arrangement. If the distributed capacities between ground and opposite sides of the loop are unequal, the voltages of the loop sides with respect to ground will cause unequal currents to flow through the coupling transformer primary, which results in distortion of the antenna pattern.

To avoid this condition, the loop is enclosed within a conductive (Faraday) shield, thus providing equal capacities to ground. The gap in the shielding (at the top of the loop) prevents the shield from behaving as a short-circuited turn. The shield also greatly reduces the response of the loop to the electric field; therefore, the loop is predominately responsive to the magnetic field.

### 5.4.1 Single Loop Response

The response pattern of a loop antenna is a figure 8. The response pattern ($E_R$) of a vertical-axis loop relative to a vertically polarized signal of specified frequency arriving horizontally at an angle $\theta$ to the plane of the loop is $E_R = 2E \sin\frac{\triangle \cos\theta}{2}$.

This is the general expression for a one-turn loop with any spacing, $\Delta$ radius, and E is the voltage induced in one vertical side. If the signal arrives at an angle of 90 degrees to the plane of the loop, the value $E_R$, or response, will be at a minimum, representing a null condition:

$$E_R = 2E \sin \frac{\Delta \cos \theta}{2} = 2E \sin 0 = 0$$

The value, $E_R$, will be maximum when the signal arrives at an angle of zero degrees to the plane of the loop. In this case, the value of the term $\frac{\Delta \cos \theta}{2}$ becomes maximum, (cos 0 = 1).

Section VI

# MAINTENANCE

## 6.1 INTRODUCTION

This section of the manual contains information for minimum performance procedures, disassembly procedures, alignment procedures, and fault isolation procedures for the Model 94593-1. The minimum performance test procedures are intended to verify that the Model 94593-1 is functioning in accordance with the specification requirements listed in Section II.

No scheduled, periodic maintenance is required.

## 6.2 MINIMUM PERFORMANCE TEST PROCEDURES

No minimum performance test procedure is provided because of the extreme complexity of the test set-up requiring the establishment of standard RF fields. If certification of antenna correction factor is required, either send the antenna to a qualified calibration lab such as the National Bureau of Standards, or return it to the factory for certification.

## 6.3 DISASSEMBLY PROCEDURES

a. Remove the 4 screws on the rear panel and remove the panel.

b. If desired, access to the PC board may be obtained by unsoldering the loop input connections at the top of the PC board and removing the four corner screws.

## 6.4 ALIGNMENT PROCEDURES

a. No alignment is necessary for the Model 94593-1.

## 6.5 FAULT ISOLATION PROCEDURE

a. Because of the simplicity of the circuitry in the Model 94593-1, no Fault Isolation Procedure is given. Use normal troubleshooting procedures to isolate the fault.

Section VII

# REPLACEABLE PARTS

## 7.1 INTRODUCTION

This section contains information for ordering replacement parts. Tables 7-1, 7-2 and 7-3 list the parts according to their functional grouping. Parts are listed in alpha-numerical order of their reference designators and indicate the description, the Singer part number, typical manufacturer of the part in a five-digit code, and the manufacturer's part number. Table 7-4 lists the typical manufacturers in numerical code number order.

Table 7-1. Main Assembly and Chassis Parts List

| Ref. Desig. | Description | Singer Part No. | Mfr. Code No. | Mfr. Part No. |
|---|---|---|---|---|
| A1 | P.C. Board Assembly | 1-004902-001 | 88869 | |
| J1 | Connector, jack, BNC, bulkhead | 1-910132-002 | 11636 | UG-1094/U |
| J2 | Connector, jack, BNC, bulkhead | 1-910132-002 | 11636 | UG-1094/U |
| J3 | Connector, jack, BNC, bulkhead | 1-910132-002 | 11636 | UG-1094/U |
| J4 | Connector, jack, box mounting, 19 pins | 1-910212-001 | 77820 | SP02SE-14-19P |
| J5 | Connector, jack, binding post | 1-941018-003 | 58474 | DF21BC |
| J6 | Connector, jack, binding post | 1-941018-001 | 58474 | DF21RC |
| S1 | Switch, rotary, 1 pole, 9 positions | 1-403641-001 | 88869 | |
| | Arm, Loop Antenna (3 required) | S52707 | 88869 | |
| | Cable, 10 3/4 ft., BNC to BNC | S94030-1 | 88869 | |
| | Mast assembly, Loop Antenna | S94031-1 | 88869 | |

Table 7-2. Supplied Accessories Parts List

| Qty | Description | Singer Part No. | Mfr. Code No. | Mfr. Part No. |
|---|---|---|---|---|
| 1 | Antenna Calibration Chart | 1-403692-001 | 88869 | |
| 1 | Instruction Manual | 1-500783-277 | 88869 | |

Table 7-3. P.C. Board Assembly, A1, Parts List

| Ref. Desig. | Description | Singer Part No. | Mfr. Code No. | Mfr. Part No. |
|---|---|---|---|---|
| C1 | Capacitor, fixed, plastic, 0.1 $\mu$F, $\pm$10%, 250 Vdc | 1-900001-113 | 73445 | C280AE, .1 $\mu$F |

Table 7-3. P.C. Board Assembly, A1, Parts List (Continued)

| Ref. Desig. | Description | Singer Part No. | Mfr. Code No. | Mfr. Part No. |
|---|---|---|---|---|
| CR1 | Diode, silicon, Vr = 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR2 | Diode, silicon, Vr = 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR3 | Diode, silicon, Vr - 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR4 | Diode, silicon, Vr = 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR5 | Diode, silicon, Vr = 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR6 | Diode, silicon, Vr = 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR7 | Diode, silicon, Vr - 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR8 | Diode, silicon, Vr = 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR9 | Diode, silicon, Vr = 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR10 | Diode, silicon, Vr = 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR11 | Diode, silicon, Vr = 75 V, If - 10 mA | 1-913007-001 | 03508 | 1N4148 |
| CR12 | Diode, silicon, Vr = 75 V, If = 10 mA | 1-913007-001 | 03508 | 1N4148 |
| K1 | Relay, 1 pole, 1 position, Coil: 12 Vdc, 4 mA, 3050 ohm | 1-942017-001 | 0000A | 206-00049 |
| K2 | Relay, 1 pole, 1 position, Coil: 12 Vdc, 4 mA, 3050 ohm | 1-942017-001 | 0000A | 206-00049 |

Table 7-3. P. C. Board Assembly, A1, Parts List (Continued)

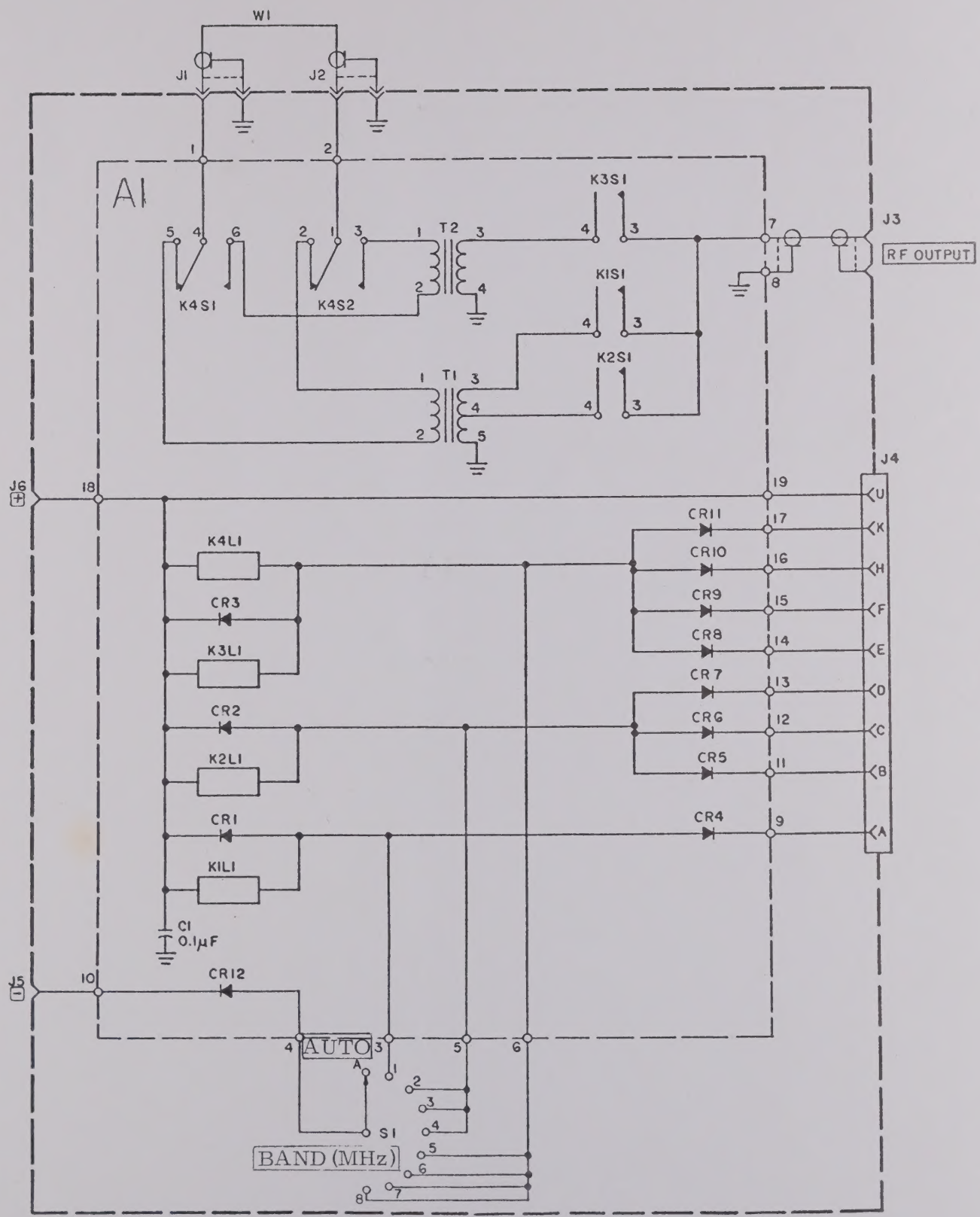
| Ref. Desig. | Description | Singer Part No. | Mfr. Code No. | Mfr. Part No. |
|---|---|---|---|---|
| K3 | Relay, 1 pole, 1 position, Coil: 12 Vdc, 4 mA, 3050 ohm | 1-942017-001 | 0000A | 206-00049 |
| K4 | Relay, 2 pole, 2 position, Coil: 12 Vdc, 12 mA, 1025 ohm | 1-942025-001 | 0000A | 205-002-12 |
| T1 | Transformer, RF, Secondary Inductance: 5 mH min | 3-403656-001 | 88869 | |
| T2 | Transformer, RF Secondary Inductance: 50 $\mu$H min | 3-403657-001 | 88869 | |

Table 7-4. Code List of Manufacturers

| Mfr. Code No. | Manufacturer | Address |
|---|---|---|
| 03508 | GE Semiconductor Prod. Div. | Syracuse, N. Y. |
| 11636 | Kings Electronics Co. | South Pasadena, Calif. |
| 58474 | Superior Electric Co. | Bristol, Conn. |
| 73445 | Amperex Electronics Co. | Hicksville, NY |
| 77820 | Bendix Corp. | Sidney, NY |
| 88869 | Singer Instrumentation | Los Angeles, Calif. |

The following vendor has no number assigned in the latest supplement to the Federal Supply Code for Manufacturers, H4-2.

| Mfr. Code No. | Manufacturer | Address |
|---|---|---|
| 0000A | Triridge Corp. | Pittsburgh, Penn. |




1. ALL DIODES ARE IN4148.

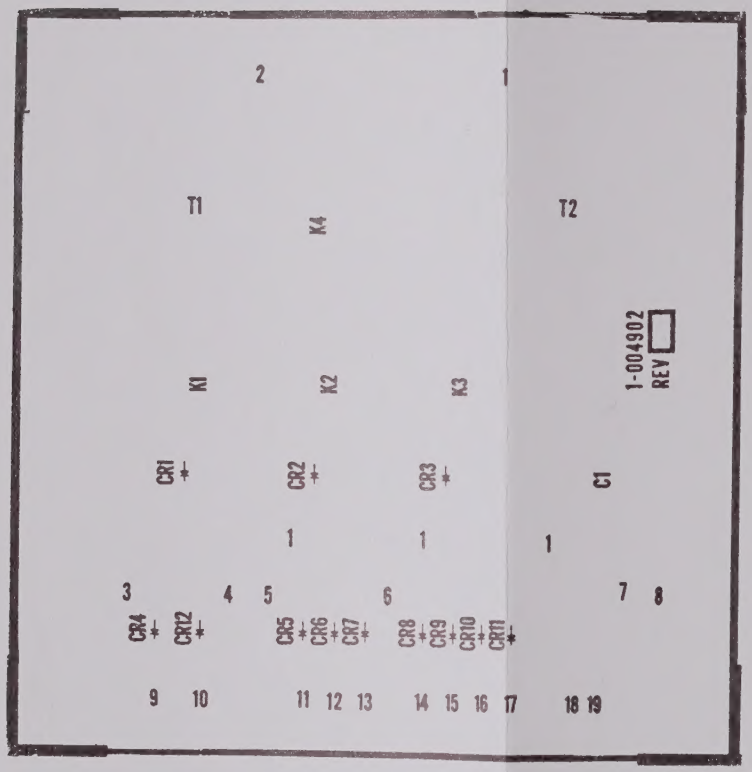



Figure 8-1. Schematic Diagram, Programmable Loop Antenna/Coupler, Model No. 94593-1. Drawing No. 4-501388-001.